



## ESHMC Training – Tools for Simulating Curtailment with ESPAM2.0

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June 15, 2012

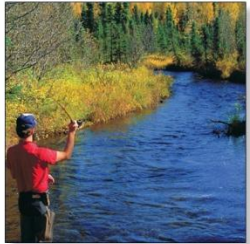


## **OVERVIEW**

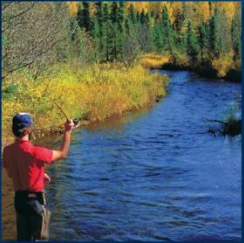
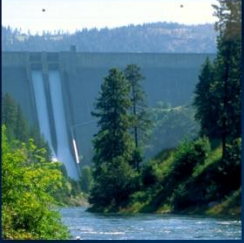
- **Curtailment IAR Tool**
  - Calculates junior irrigated land area by model cell and groundwater irrigation entity
  - Writes IAR file
- **MKMOD**
  - Calculates crop irrigation requirement by model cell and groundwater irrigation entity
  - Writes well file and summary table
- **MODFLOW**
  - Calculates response to applied stress
  - Writes binary head and water budget files
- **BUD2SMP**
  - Processes binary water budget file

## GETTING STARTED

- Install required software
- Download input files
- Links provided in handout

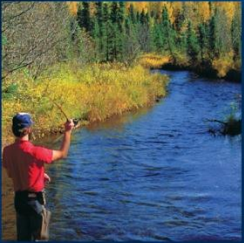






## CURTAILMENT IAR TOOL INPUT DATA

- 2012 POD file (or most current)
  - Provides data used to calculate junior priority fraction by model cell
  - Locations of groundwater PODs from IDWR water right database
  - Water right priority date
    - Adjusted to subordinate date for enlargements
  - Irrigation diversion rate
    - Water right rate divided by number of PODs



## CURTAILMENT IAR TOOL INPUT DATA

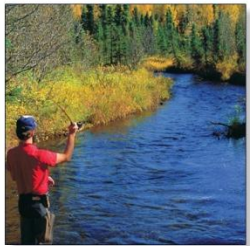
- 2008 Irrigated Lands Raster (or most current)
- Average Groundwater Fraction Raster
- Wetlands/Urban Mask
- Groundwater Entity Raster
- Surface Water Entity Raster

## **CURTAILMENT IAR PROCESSING STEPS**

- Calculate junior priority fraction by model cell
  - Uses same algorithm as pdate.exe from ESPAM1.1 tools
  - Basis:  $\text{Junior CFS} / \text{Total CFS} \sim \text{Junior CU} / \text{Total CU}$ 
    - Tested by IWRRI (2004)
    - [http://www.idwr.idaho.gov/Browse/WaterInfo/ESPAM/meetings/2012\\_ESHMC/04\\_16\\_2012/VB\\_P\\_DIV\\_FRAC.zip](http://www.idwr.idaho.gov/Browse/WaterInfo/ESPAM/meetings/2012_ESHMC/04_16_2012/VB_P_DIV_FRAC.zip)

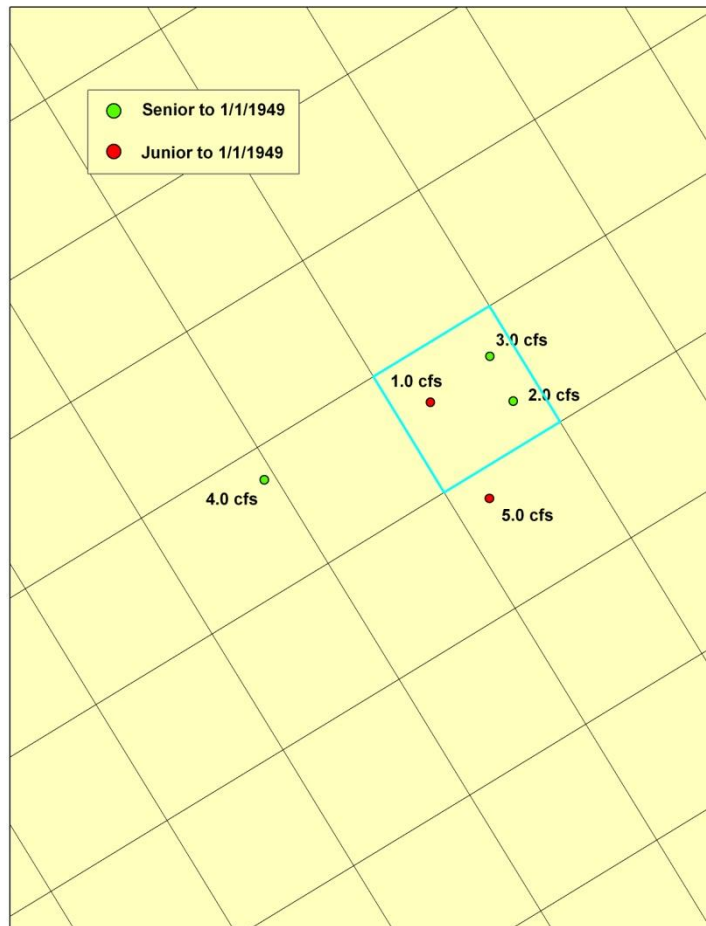
## CURTAILMENT IAR PROCESSING STEPS

- Calculate junior priority fraction by model cell
  - Read user-specified priority date
  - Calculate POD diversion rate by model cell
  - Calculate POD diversion rate junior to user-specified date by model cell
  - If a cell has no PODs, it is assigned the junior fraction calculated from the eight adjacent cells
  - If none of the eight adjacent cells have PODs, the cell is assigned to global junior fraction
  - If cell is in Mud Lake or Montevieu place of use, junior fraction is calculated based on PODs in well field and place of use cells





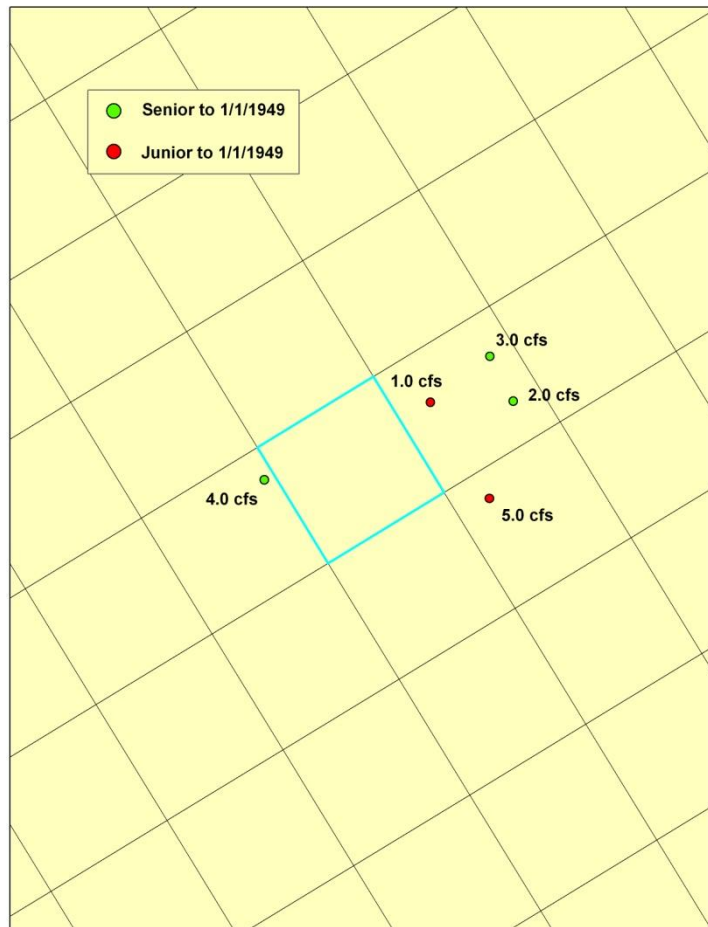
## CURTAILMENT IAR PROCESSING STEPS



- Example – cell with PODs
- Cell irrcfs =  $1+2+3 = 6$
- Junior irrcfs = 1
- Junior fraction =  $1/6 = 0.16667$



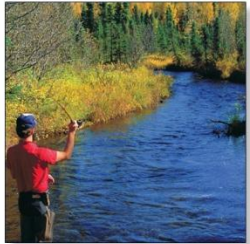
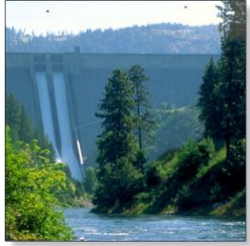
# CURTAILMENT IAR PROCESSING STEPS



- Example – cell without PODs
- Adjacent cells irrcfs =  $4+1+2+3+5 = 15$
- Junior irrcfs =  $1+5 = 6$
- Junior fraction =  $6/15 = 0.40$

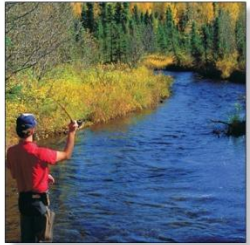
## CURTAILMENT IAR PROCESSING STEPS

- Calculate groundwater irrigated lands by model cell and irrigation entity
  - Same process as IAR Tool used to calculate irrigated area for calibration
  - Remove wetlands and urban areas from irrigated lands
  - Apply groundwater source fraction to determine groundwater irrigated lands
  - Assign irrigated lands to model cell and irrigation entity (IEGW500, IEGW501, etc.)



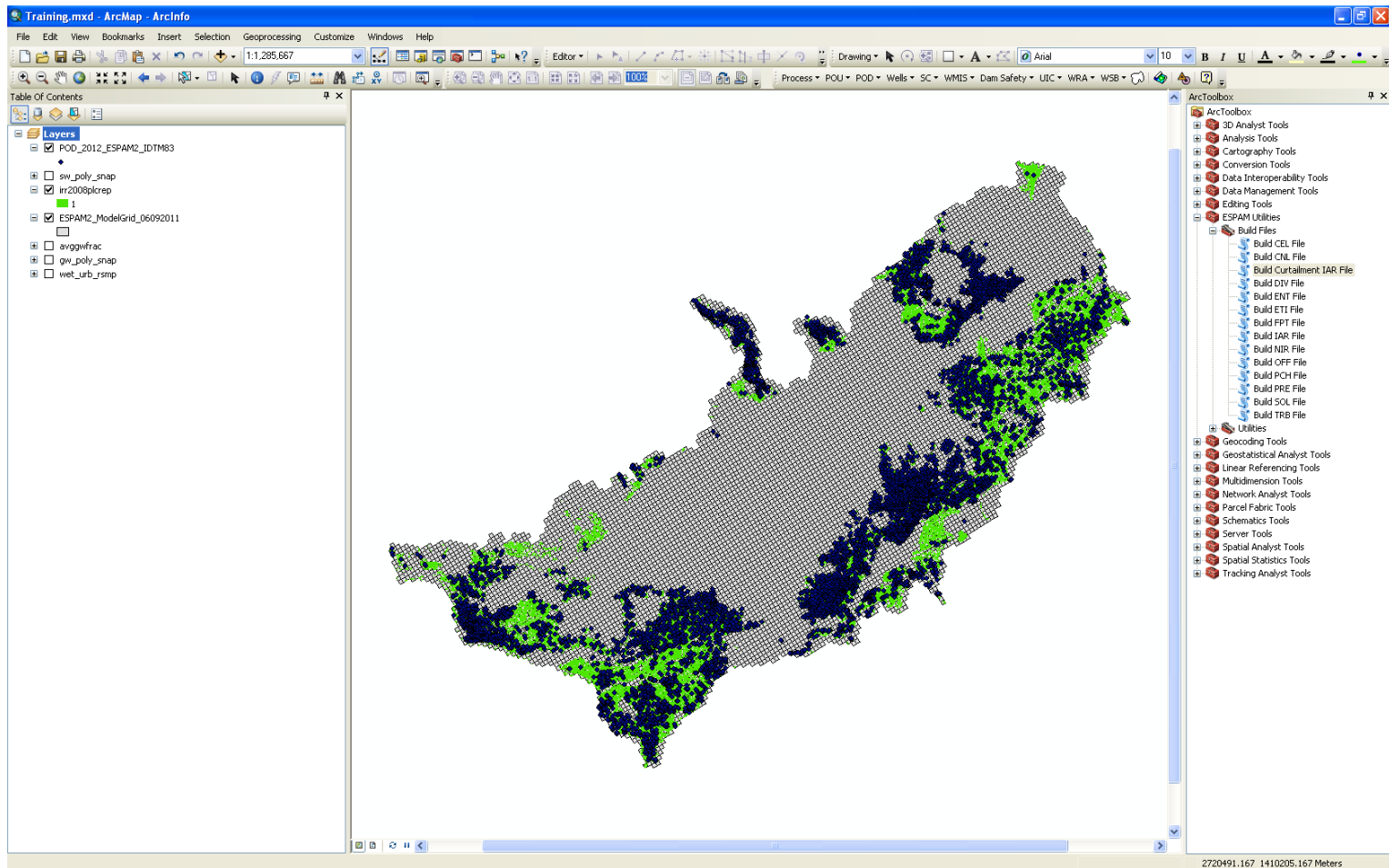
## CURTAILMENT IAR PROCESSING STEPS

- Apply user specified multipliers to irrigated lands
  - Multiply groundwater irrigated lands by -1 to model injection
  - Multiply surface water irrigated lands by zero to remove from data set
- Apply junior priority fraction to groundwater irrigated lands





## RUNNING CURTAILMENT IAR TOOL FROM ARC TOOLBOX



## **RUNNING CURTAILMENT IAR TOOL FROM COMMAND LINE**

- Syntax: `espamtool -t curtailment -o <Output IAR File> --sp=<Number of Stress Periods> -r <Output Raster Directory> -p <Priority Date in MM-DD-YYYY> --est-flag <A|G> --gw-multiplier=<Ground Water Multiplier> --sw-multiplier=<Surface Water Multiplier>`
- Example: `espamtool -t curtailment -o D:\ESPAM2\TEST\out.iar -r D:\ESPAM2\TEST --sp=1 -p 1-1-1949 --est-flag=A --gw-multiplier=-1 --sw-multiplier=0`

# LUNCH BREAK





## **BASE FILES FOR MKMOD**

- MKMOD requires all 16 input files
- NULL\_BASE file set has all recharge components set to zero
- ET and precipitation by model cells are 10-year average for November 1998 – October 2008
- Replace one input file to simulate response to a single component of recharge in superposition mode
- Example: Replace IAR file with output from Curtailment IAR Tool to simulate response to curtailment

# MDL FILE FOR STEADY STATE SIMULATIONS

Null.mdl file is designed for use in steady state simulations with **average annual values** in Null.ETI and Null.PRE files. Adjustment factors for NIR and wetlands are from calibration run E120116A008.

DAYS

FEET

1 1 1

**365.25 SS**

Steady state stress period is 365.25 days  
for use with annual ET and precipitation

104

209

1

1

11

0.6549132000 0.3265008000 1.023259000 1.374128000 1.056037000 0.8122819000 0.4277097000 1.013269000  
0.8170578000 0.83537600000 0.57209960000 1.00111300

4

W PPT Wetlands Correction

U WEL Urban Pumping

E WEL Exchange Pumping

M WEL MudLake Pumping

1

rfx ROF IESW009+IESW020+IESW055

-43560

## MDL FILE FOR SEASONAL TRANSIENT SIMULATIONS

Monthly\_Null.mdl file is designed for use in 10-yr seasonal transient simulations with average monthly values in Monthly\_Null.ETI and Monthly\_Null.PRE files.

Adjustment factors for NIR and wetlands are from calibration run E120116A008.

DAYS

FEET

**120** 1 12

Edit number of stress periods for simulations <>10 years

30 04/**2012**

Edit stress period years if desired. First stress period must be April if Monthly\_Null.ETI and Monthly\_Null.PRE are used.

31 05/2012

30 06/2012

31 07/2012

31 08/2012

30 09/2012

31 10/2012

30 11/2012

31 12/2012

February stress period is 28.25 days for use with average monthly ET and precipitation

31 01/2013

**28.25** 02/2013

31 03/2013

Add or delete stress periods for simulations <>10 years

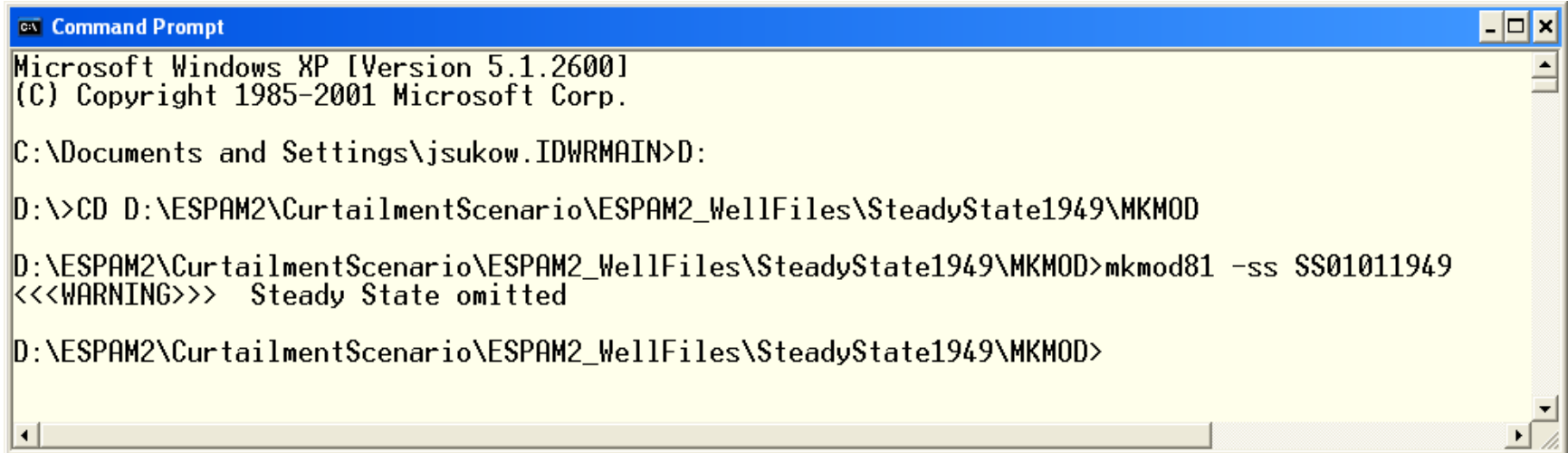
30 04/2013

31 05/2013

30 06/2013



## RUNNING MKMOD



```
C:\ Command Prompt
Microsoft Windows XP [Version 5.1.2600]
(C) Copyright 1985-2001 Microsoft Corp.

C:\Documents and Settings\jsukow.IDWRMAIN>D:

D:\>CD D:\ESPAM2\CurtailmentScenario\ESPAM2_WellFiles\SteadyState1949\MKMOD

D:\ESPAM2\CurtailmentScenario\ESPAM2_WellFiles\SteadyState1949\MKMOD>mkmod81 -ss SS01011949
<<<WARNING>>> Steady State omitted

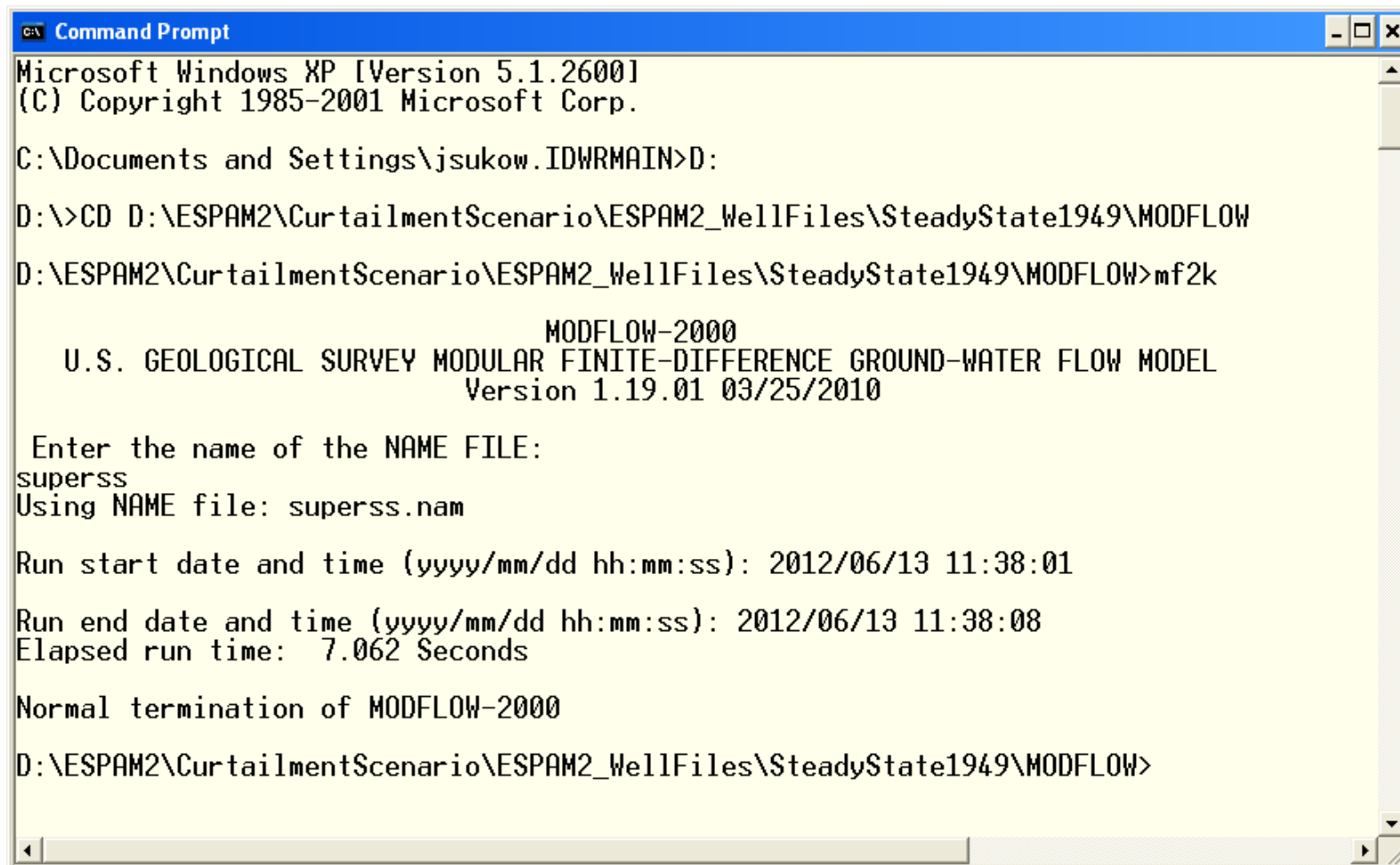
D:\ESPAM2\CurtailmentScenario\ESPAM2_WellFiles\SteadyState1949\MKMOD>
```

- -ss directs MKMOD to omit steady state period from well file
- \*.htm file provides tables summarizing water budget
- \*.net file provides net recharge in MODFLOW well file format

## **MODFLOW FILES FOR SUPERPOSITION**

- Posted with training materials on website
- Superposition files for steady state simulations
- Superposition files for 10-yr monthly transient simulations
- Superposition files for 150-yr transient simulations with constant stress
- Add well file (MKMOD output) and edit name file

## RUNNING MODFLOW



```
C:\ Command Prompt
Microsoft Windows XP [Version 5.1.2600]
(C) Copyright 1985-2001 Microsoft Corp.

C:\Documents and Settings\jsukow.IDWRMAIN>D:

D:\>CD D:\ESPAM2\CurtailmentScenario\ESPAM2_WellFiles\SteadyState1949\MODFLOW
D:\ESPAM2\CurtailmentScenario\ESPAM2_WellFiles\SteadyState1949\MODFLOW>mf2k

                                MODFLOW-2000
      U.S. GEOLOGICAL SURVEY MODULAR FINITE-DIFFERENCE GROUND-WATER FLOW MODEL
                                Version 1.19.01 03/25/2010

Enter the name of the NAME FILE:
superss
Using NAME file: superss.nam

Run start date and time (yyyy/mm/dd hh:mm:ss): 2012/06/13 11:38:01
Run end date and time (yyyy/mm/dd hh:mm:ss): 2012/06/13 11:38:08
Elapsed run time: 7.062 Seconds

Normal termination of MODFLOW-2000

D:\ESPAM2\CurtailmentScenario\ESPAM2_WellFiles\SteadyState1949\MODFLOW>
```



# POST-PROCESSING MODFLOW OUTPUT

- LST file
- Post-processing binary budget file with BUD2SMP

```

Command Prompt
Microsoft Windows XP [Version 5.1.2600]
(C) Copyright 1985-2001 Microsoft Corp.

C:\Documents and Settings\jsukow.IDWRMAIN>d:
D:\>cd D:\ESPAM2\CurtailmentScenario\ESPAM2_WellFiles\SteadyState1949\MODFLOW
D:\ESPAM2\CurtailmentScenario\ESPAM2_WellFiles\SteadyState1949\MODFLOW>bud2smpcb2sghb.in

Program BUD2SMP writes a bore sample file of MODFLOW-generated
inflows/outflows within user-specified zones.

Note: This program reads a MODFLOW or MT3D unformatted file. Sometimes there
are problems in reading files of this type due to incompatibilities between
different FORTRAN compilers. If there are any such problems please contact
john.doherty@ozemail.com.au and I will send you an alternative copy of this
program.

Enter name of grid specification file: - grid specifications read from file espam2.gsf
How many layers in model?
Enter name of MODFLOW unformatted budget output file: Is this a MODFLOW88 or MODFLOW96 budget file [8/9]? Enter maxi
mum number of output times: Enter text to identify MODFLOW flow type:
Enter simulation starting date [mm/dd/yyyy]: Enter simulation starting time [hh:mm:ss]: Enter time units employed by
model [y/d/h/m/s]:
Enter name of integer array file for layer 1: - integer array read from file KimBullsfKh.inf

A total of 3 different non-zero zones were identified in integer arrays.
An identifier must now be provided for each zone to appear in the bore
sample output file:-
Enter identifier for flows in zone 1 (10 characters or less): Enter identifier for flows in zone 2 (10 characters
or less): Enter identifier for flows in zone 3 (10 characters or less):
Enter name for bore sample output file: Enter flow rate factor: Assign flows to beginning, middle or finish of time s
tep? [b/m/f]:
Enter name for run record file:
- data for 1 model output arrays written to file mod_GHB.smp
- see file mod_GHB.rec for a record of arrays found in file SuperSS.bud

D:\ESPAM2\CurtailmentScenario\ESPAM2_WellFiles\SteadyState1949\MODFLOW>_

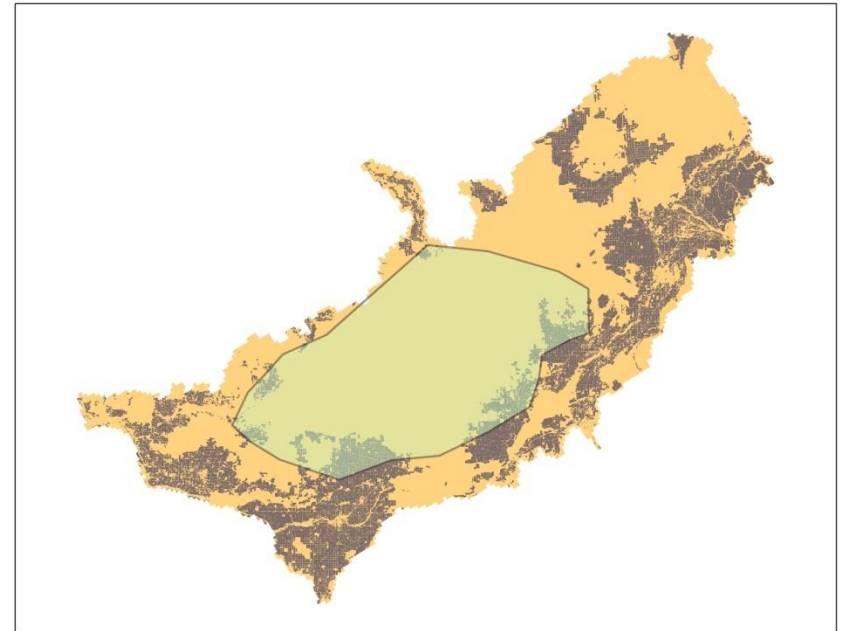
```

- Binary head file can be processed with MOD2SMP or MOD2OBS

**BREAK**

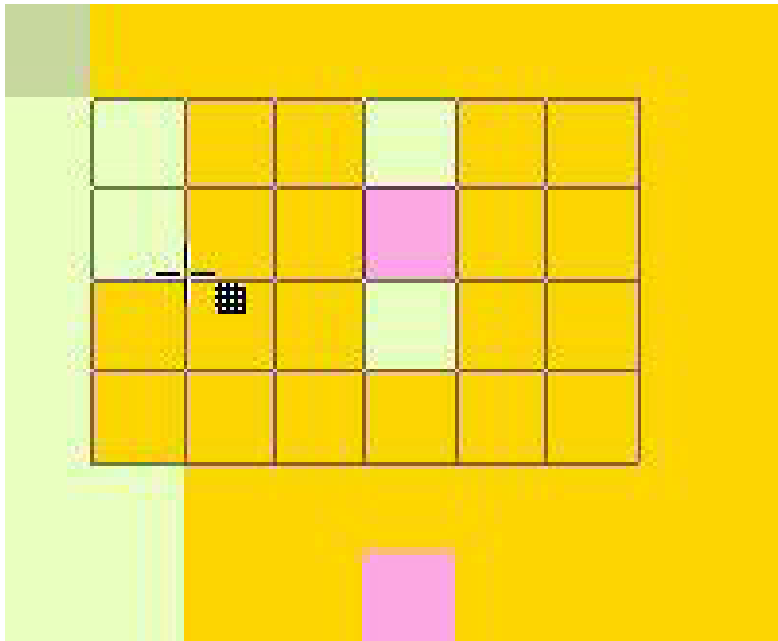
## RASTER PROCESSING TIPS

- Recommendations for clipping rasters
  - Use a snap raster to maintain raster alignment
  - Clip tool in the ArcToolbox Data Management tools is preferred method
  - Extract by Mask tool may also be used, but creates a file of larger size

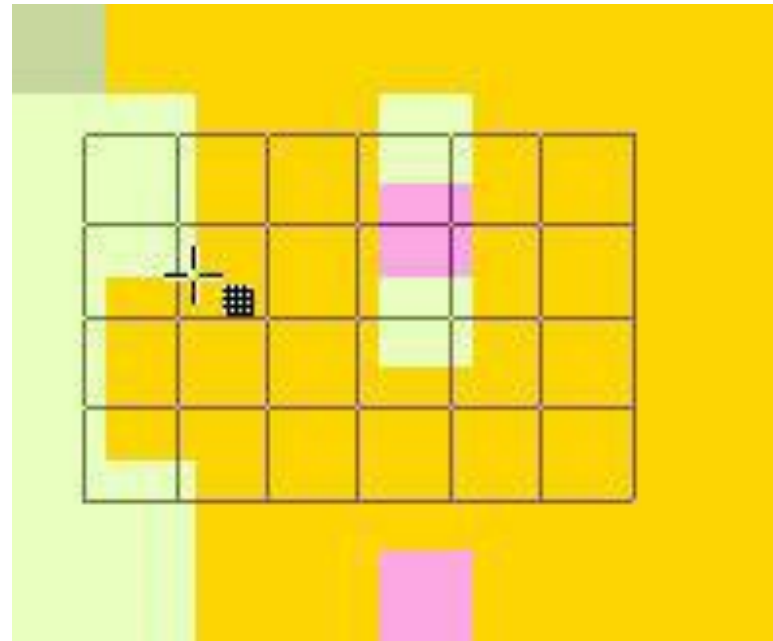


## Aligning rasters to common pixel grid

### Good raster alignment



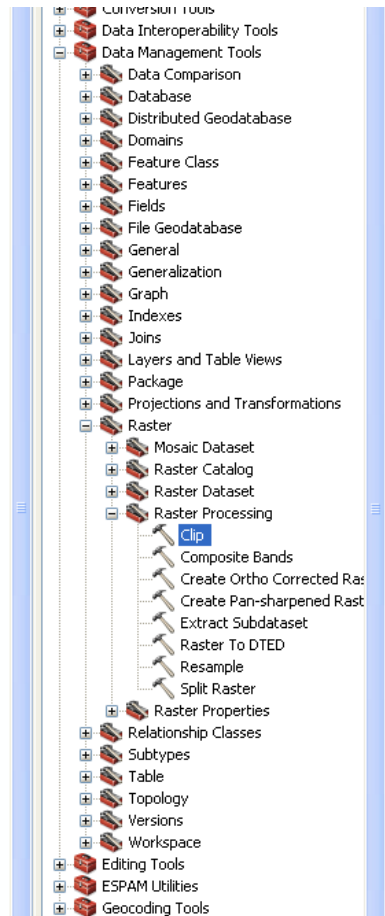
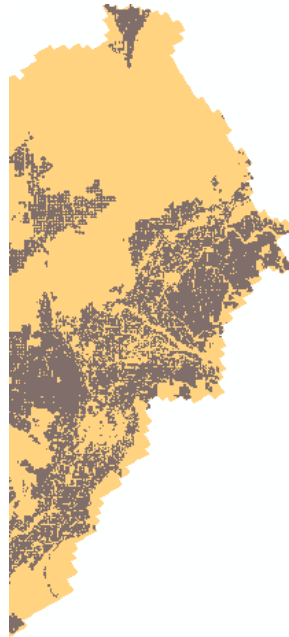
### Bad raster alignment



Rasters provided in NULL data are aligned to origin of (15m,15m)  
and have 30m x 30m pixel size



# CLIPPING RASTERS



# CLIPPING RASTERS

The screenshot shows the 'Clip' tool dialog box in ArcGIS. The 'Input Raster' is set to 'irr2008plcrep'. The 'Output Extent (optional)' is set to 'GenericShape'. The 'Rectangle' section has the following values: X Minimum: 2469869.489848, X Maximum: 2626456.667513, Y Minimum: 1277863.065990, and Y Maximum: 1380772.979695. The checkbox 'Use Input Features for Clipping Geometry (optional)' is checked. The 'Output Raster Dataset' is set to 'N:\Hydro\ESPAM2\_RechargeTools\Training\2008clip'. The 'NoData Value' is set to '(null)'. A callout box points to the checked checkbox with the text 'Select Use Input Features for Clipping Geometry'. Another callout box points to the 'Environments...' button at the bottom with the text 'Set snap raster in Environments'. On the right side, there is a section titled 'Use Input Features for Clipping Geometry (optional)' with explanatory text and two bullet points: 'Unchecked—The raster dataset is clipped based on the minimum bounding rectangle of the feature class.' and 'Checked—The raster dataset is clipped based on the perimeter of the polygon shape.' Below this is further text: 'If a feature within the feature class is selected and Input Features for Clipping Geometry is checked, then the output will clip out the area that is selected. If a feature within the feature class is selected but Input Features'.

**Clip**

Input Raster  
irr2008plcrep

Output Extent (optional)  
GenericShape

Rectangle

Y Maximum  
1380772.979695

X Minimum  
2469869.489848

X Maximum  
2626456.667513

Y Minimum  
1277863.065990

☒ Use Input Features for Clipping Geometry (optional)

Output Raster Dataset  
N:\Hydro\ESPAM2\_RechargeTools\Training\2008clip

NoData Value (null)

Clear

OK Cancel Environments... << Hide Help Tool Help

**Use Input Features for Clipping Geometry (optional)**

If you are using a feature class as the output extent, you have the option to clip the raster by the extent of the feature class or by the polygon perimeter.

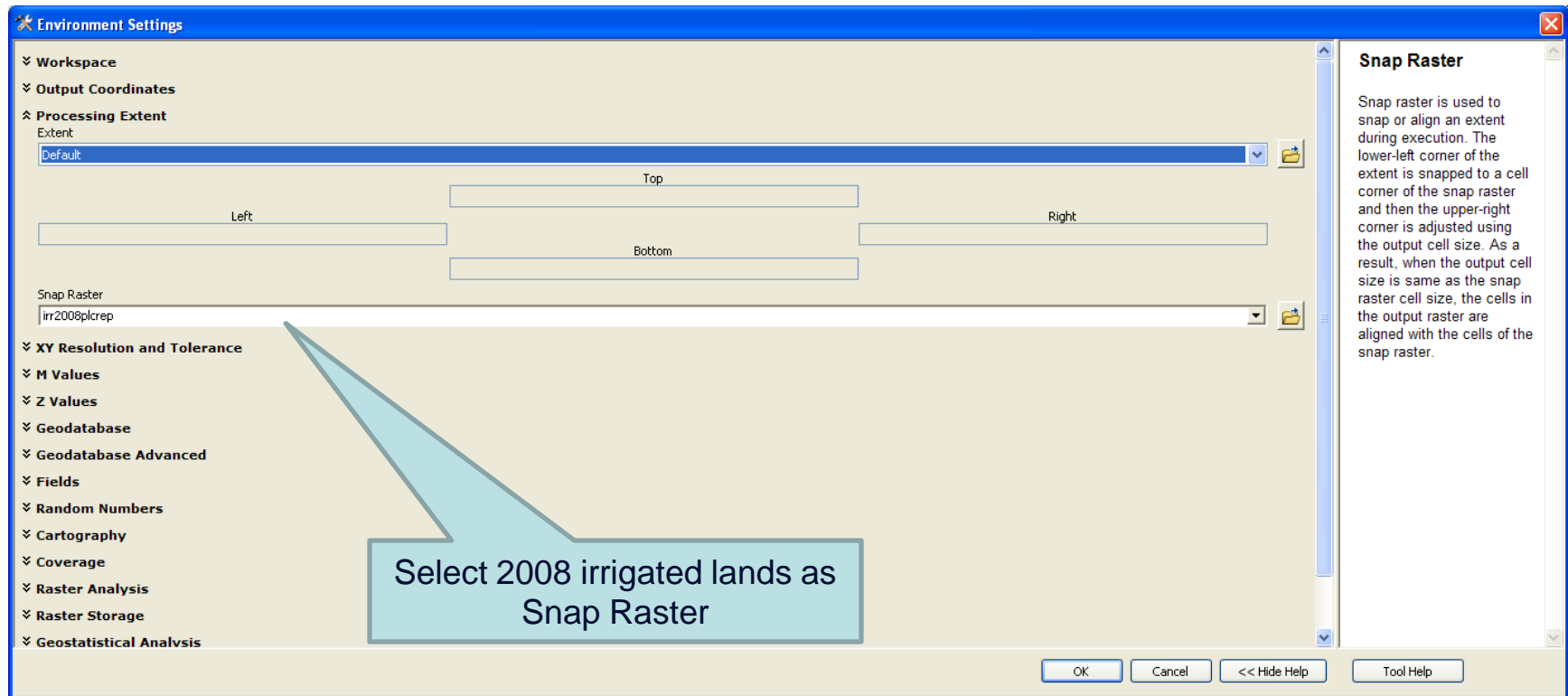
- Unchecked—The raster dataset is clipped based on the minimum bounding rectangle of the feature class.
- Checked—The raster dataset is clipped based on the perimeter of the polygon shape.

If a feature within the feature class is selected and Input Features for Clipping Geometry is checked, then the output will clip out the area that is selected. If a feature within the feature class is selected but Input Features

Select Use Input Features for Clipping Geometry

Set snap raster in Environments

# CLIPPING RASTERS



# CLIPPING RASTERS

Check alignment:  
Each extent value divided  
by 30 should have  
remainder of 15.

Example:  
 $1380795/30 = 46026.5$

**Layer Properties**

General Source **Extent** Display Symbology

You can specify the geographic extent of this layer's data source that will be represented by this layer

Set the extent to: the current setting of this layer

**Visible Extent**

Left: 2469855 Top: 1380795 Right: 2626485  
Bottom: 1277835

**Full Extent**

☒ of this layer ☐ of the data frame

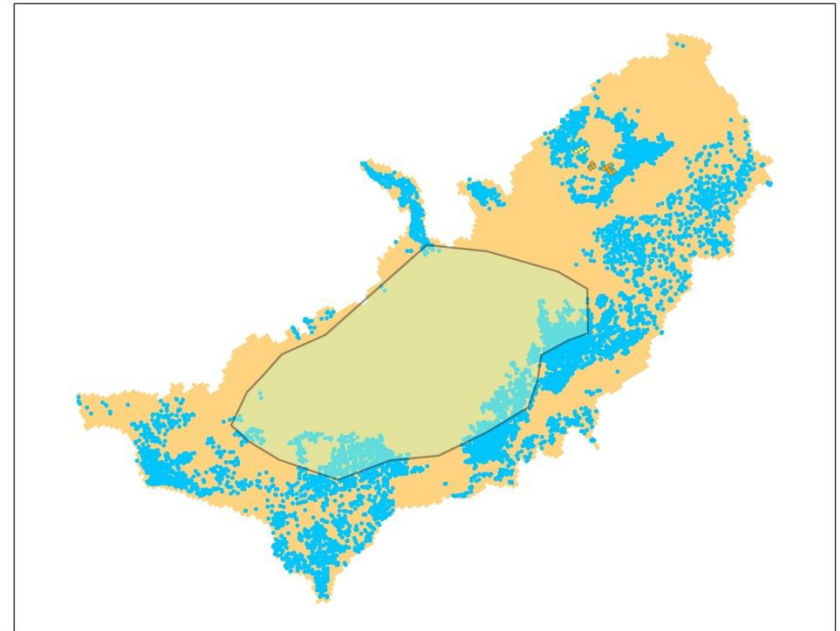
Left: 2469855 Top: 1380795 Right: 2626485  
Bottom: 1277835

OK Cancel Apply



## POD FILE PROCESSING TIPS

- Recommendations for clipping rasters
  - Usually best to clip POD file to same extent as irrigated lands file, so global priority fraction reflects area of interest
  - Use caution if clip shape splits Mud Lake/Montevieu area



## POD FILE PROCESSING TIPS

- Recommendations for clipping rasters
  - If Curtailment IAR Tool (V1.5) does not find at least one POD in each cell in the Mud Lake/Montevieu well fields, it will write a warning to IAR file
  - User will need to comment out warning or make corrections to POD file as appropriate

#ESPAM2\_ModelGrid\_06092011.shp

#sw\_poly\_snap

#gw\_poly\_snap

#wet\_urb\_rsmf

#avggwfrac

#2008plcrpclip

#POD2012clip.shp

**Warning.** There were not PODs present in each of the Mud Lake and Montevieu well field cells. If this is OK, comment out this line in IAR file.

#1949-01-01

STRESS PERIOD 1

1

5337

81 128 2

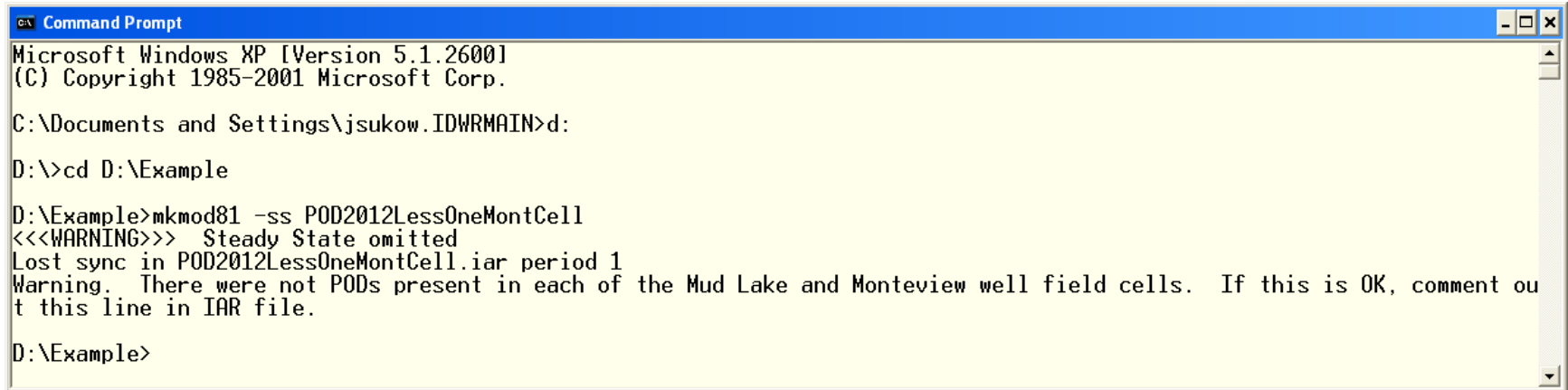
IEGW506 IESW034

-13740492 0

81 129 2

...

## POD FILE PROCESSING TIPS



```
Command Prompt
Microsoft Windows XP [Version 5.1.2600]
(C) Copyright 1985-2001 Microsoft Corp.

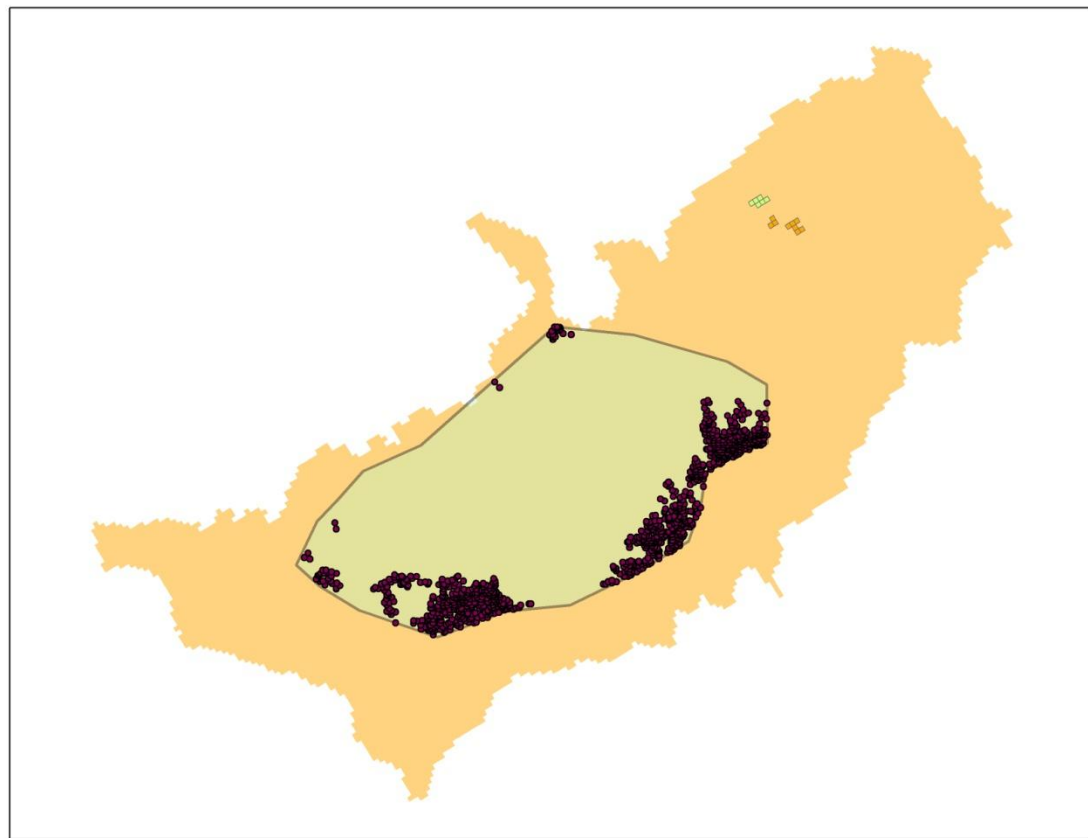
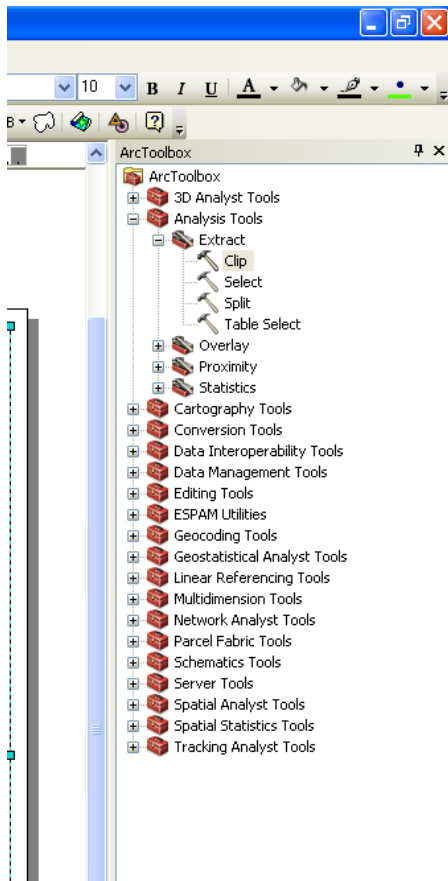
C:\Documents and Settings\jsukow.IDWRMAIN>d:

D:\>cd D:\Example

D:\Example>mkmod81 -ss POD2012LessOneMontCell
<<<WARNING>>> Steady State omitted
Lost sync in POD2012LessOneMontCell.iar period 1
Warning. There were not PODs present in each of the Mud Lake and Montevue well field cells. If this is OK, comment out this line in IAR file.

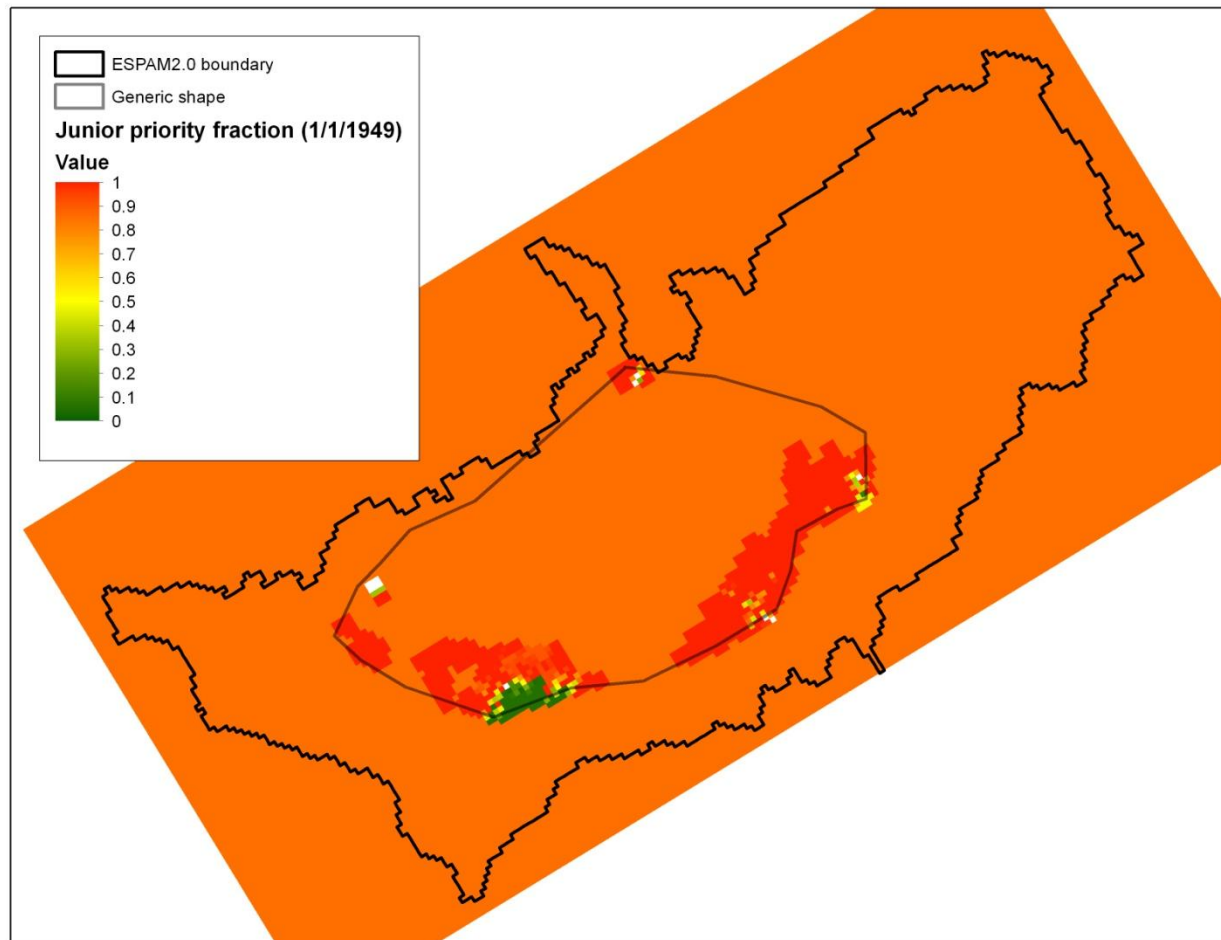
D:\Example>
```

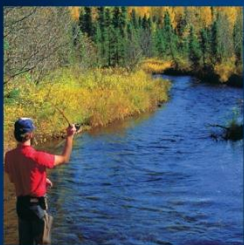
## POD FILE PROCESSING TIPS





## POD FILE PROCESSING TIPS





## WRAP UP & QUESTIONS